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Ergonomics in the Work Environment

CHAPTER CONTENTS

INTRODUCTION

Ergonomics (or "Human Factors" as it has traditionally been called) is a multi-disciplinary study of the relationships between the person and the environment. Ergonomics includes information from Engineering, Biomechanics, Environmental Psychology, Physiology and other fields about how human beings are affected by their environment, especially in the workplace. It is intended to enhance safety, productivity, and quality of life.

This guidebook offers an overview of the ways an interior designer may engage in human factor and environmental issues. It is not intended to deal with technical applications of ergonomics like industrial product design nor job task engineering. Rather, it focuses on how the designer can influence the comfort and safety of the people for whom they design.

It is generally taken for granted that all design is concerned with creating objects and spaces to serve the needs of their user. Many buildings, interiors and furnishings fall short of optimally serving human needs, however. In some cases, design has not kept up with the complexities of modern technology or the evolution of organizations. In other cases, people or agencies may have directed design with little background or awareness of the needs of users. Economic forces often exert considerable pressure, and can take precedence over information about actual requirements. Designers often assume that they know how to design for all human needs based upon personal experience, or they assume that their own requirements are typical of those of all others.

Goals

Designing the work environment ergonomically, that is, to meet the needs of the user, is critical to overall mission success. Specific goals of Air Force ergonomic programs are intended to:

- decrease the occurrence and cost of accidents, injuries and disabilities
- improve the well-being and readiness of the organization
- optimize the performance of organizational systems
- decrease physical and cognitive stress on personnel
- increase job satisfaction and productivity

Impact

Why the emphasis on ergonomics? The answer is simple: because the consequences of poorly designed objects and environments – especially at work – are serious and costly. At a minimum, poorly applied ergonomics can cause schedule delays, recurring discomfort, or a decrease in performance or output. At the extreme, the consequences can be permanent injury or even death.

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We human beings are amazingly adaptable. Practically speaking, even under the most adverse conditions, the job must somehow get done. We routinely adjust to the task, furniture or equipment that we have been given. However, there are costs associated with this adaptation. Many of the serious problems on the job fall under the categories of Cumulative Trauma Disorders (CTD), or Repetitive Motion Injuries (RMI). These costly injuries are often a specific result of the body's adaptation to a repetitive task or an inappropriate posture. Their effects are widespread and often have long term consequences.

By all accounts, there is a serious, quantifiable impact when ergonomic issues are not dealt with in the workplace. It is a rising cost that cannot be ignored, and good design is a valuable component of the solution.

Role of the Interior Designer

The ways in which a designer may use human factor information will vary with the nature and scope of individual design problems. In typical areas of responsibility, an interior designer:

- investigates and considers the needs and preferences of actual users and occupants
- chooses materials, finishes and products to meet aesthetic, practical and environmental goals
- selects furniture to fit individual and group needs
- plans the placement of elements and people in relation to natural light and ventilation
- directs or advises on space allocation or densities
- designs workstations and layouts
- guides and educates those who establish and oversee budgets about ergonomic cost/benefits
- observes workplace problems that may be indicators of poor ergonomic design

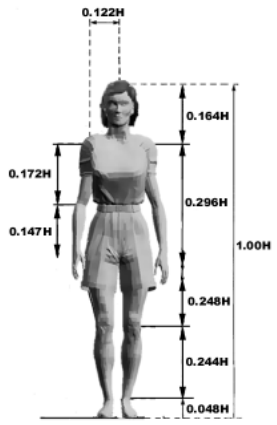
Although these concepts are obvious to most designers, they may seem strange to individual clients and to client organizations that focus on different goals and lowest possible first cost. However, there is a clear obligation on the part of every designer to make a case for social responsibility and to point out the broader benefits derived from the application of ergonomics.

ERGONOMICS AND THE HUMAN BODY

Anthropometrics

Despite the great variability in work places and job tasks, the human body serves as a constant. In order to make informed design decisions, it is important to understand how the body responds to and moves about in its environment.

A fundamental consideration for the designer is the size of the body – its spatial requirements. Measurements of population dimensions come from an area of study called "anthropometry." These findings are relevant to such design tasks as selecting furniture, allocating space or placing equipment.



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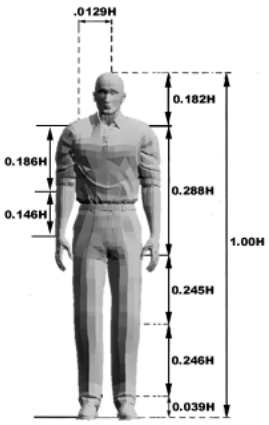


Height Distribution

	in.	cm
5%	64.4	164
10%	65.7	167
50%	68.7	174
90%	71.7	182
95%	73.0	185

Anthropometry can provide the dimensions of an entire population or a target range within that population. Manufacturers often target measurements to the 50th percentile, or so-called "average" user. All this means is that 50% of the population are larger and 50% are smaller. By this definition, "average" does not really exist, and it is dangerous to design to this standard alone.

In more cases, it is necessary to design for an entire range of a population, from the smallest to the largest of those likely to use the particular space or equipment over time. For example, the height of cabinets or storage space might be set so that 90 percent of a typical office population can reach it, whereas a doorway may be designed so that 99 percent of the entire population can pass through it without stooping.

As a point of departure, the interior designer should consider criteria that cover the size of the fifth percentile of the adult female population through the 90th percentile of the adult male population. At left are some frequently used measurements.

It is also important to understand the inherent limitations of anthropometric data, and why they should be used as guidelines rather than hard and fast mandates. First, there is no one set of data that has been universally agreed upon. It is not uncommon to find values listed in different sources that vary by several inches for the same measurement.

Also, it should be obvious that the applicability of any measurements used in a design solution depends upon the similarity between the population studied and the population who will be performing the task or using the product.

The designer should also refer to the provisions of the Americans with Disabilities Act (ADA) to ensure that reasonable accommodation of the disabled is taken into consideration. An informed designer will be able to achieve the best fit between the individual and his or her environment.

Body Posture

The selection and placement of furniture and equipment will also determine the postural requirements in a workplace. Ergonomic research used to stress the importance of maintaining the body in a "neutral" position for as long as possible to minimize the stress on muscles and joints. Current research indicates that in addition to maintaining healthful posture, it is important for the individual to vary or alternate pressure points and body positions at will. This will allow the body to increase its available strength, postpone fatigue, and minimize the likelihood of injury. Whenever possible, a design scheme should accommodate this need for the body to change positions. Providing spaces for people to walk short distances, adjust their chairs or to alternate between seated and standing tasks can have a healthful effect.

Stressors

We know that maintaining any posture or performing any movement exerts force on, or stresses, the body. These stresses exist somewhat in any situation, although they are not necessarily hazardous. Whether or not they have a

negative effect depends upon the amount of demand imposed on the individual through exertion, intensity, duration or repetition. It can also be a combination of these factors which produces dramatic increases in work effort, fatigue, pain, discomfort and injury.

An example of a stressor is the amount of force required in moving or lifting an object, such as opening a file cabinet or raising a flipper to retrieve an item from overhead. It is important that the strength requirements are within the level of the capabilities of the population who will be performing the task.

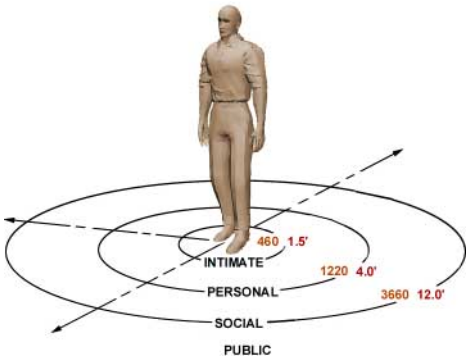
Some stressors can be reduced by simple rearrangement once the ergonomic risk has been identified. In other cases, it is necessary to replace furniture or products that are dated or dangerous with newer, more ergonomically designed products. One example is the selection of overhead storage units with a hydraulic assist on the flipper. The unit can be the same size as the one it replaces, but the amount of effort required to operate it is much lower. Consider user ease and access when making purchasing or placement decisions.

ERGONOMICS AND HUMAN PSYCHOLOGY

Personal Space

Studies have shown that the design and condition of one's space contributes directly to feelings of comfort, motivation, safety, stress tolerance, and well being. This "state of mind" in turn, effects error rate, fatigue, accident rates, productivity and quality of work.

The effects of population density have important implications for the interior designer, and the basic standards for space allocation are covered in this guide. In addition to needing enough space to move about and perform various tasks, people react to space in a variety of ways, depending upon their culture and conditioning.



Researchers have defined the space surrounding the individual in terms of the way in which people in a given culture typically respond to others. "Intimate space" is that area immediately surrounding the individual's body. This area is most private and inviolate to the individual. A person tends not to allow any one to intrude in intimate space unless intimate relationships are expected. "Personal Space" is that area in which a person tends to allow only selected friends or fellow workers with whom personal discussion is desired. "Social space" or "Distant Personal Space" is that area within which the individual expects to make purely social contacts on a temporary basis. In addition, finally, "Public Space" is that area within which the individual does not expect to have direct contact with others.

Obviously, the more intimate the spatial relationship becomes, the more people resist intrusion by others. If their implied limits or boundaries are breached, tension or anxiety can result. While absolute distance criteria are not applicable, the following approximations are useful design considerations.

Typical Subjective Responses to Spatial Features

It is important to recognize how people may feel when they interface with the architectural features in their environment. Again, attitudes toward privacy, reliance on subtle cues to signal their intentions or desires, and attitudes toward work in general are culturally influenced, but some generalizations can be helpful.

- *Size (generally volume).* If the space is too small for the number of people, furnishings, equipment or other objects, people will consider it crowded. They may accept a crowded condition on a temporary basis, they will object to working or living in such a space for extended periods of time, and anxiety and stress-related problems will surface. If the space is too large, people will consider it "unfriendly" and inconvenient.

- *Shape (generally proportion).* If a space is out of proportion (too narrow, wide, high, etc.), people will consider it distracting or oppressive. If the space contains distortions such as all curved surfaces, acute wall junctures, and too many projections or surface changes, people will consider it confusing and difficult to maneuver. When a ceiling is extremely high relative to the lateral dimension of the space, people feel as if they are working in a pit, or that the walls are closing in on them. When a ceiling is extremely low, and the space in front of the viewer is very long, people feel like the room is uncomfortably "endless." To compensate, they may instinctively duck their heads or hold their heads in an unhealthful posture.

- *Color and illumination.* If a space is too dark, people tend to be less active, or they may feel anxious. If a space is too bright, people may feel overly exposed, or they will complain of glare or thermal discomfort. If there are too many different colors, too large an expanse of very saturated color, or too many "busy" patterns of color within a space, people will become irritated after more than a brief exposure to the space. If there is too little color, no visual pattern, texture, or other decorative break in the visual environment, people will find the space monotonous, and irritating to the point of subconsciously wanting to escape.

- *Windows.* Generally, most people do not like to live and work in a space that is devoid of windows. First, people seem to need some sort of contact with the outside world for reassurance and the perception of safety. On the other hand, too many windows, or oversized windows such as the floor to ceiling type, can cause the following negative reactions: glare, over-exposure ("fishbowl" effect), vulnerability or anxiety.

- *Attractiveness.* Good design is, in itself, healthful. People experience feelings of comfort, ownership, and mastery in attractive surroundings. Self-esteem can also improve when an individual is placed in a well-designed and well-maintained environment. A luxurious setting has the psychological effect of making people speak more quietly.

- *Proximity to others.* People enjoy watching other people, but they do not like to be in situations where they can be directly observed. People especially do

not like to encounter others as they come out of the restroom. Generally, individuals like to be seated so that the entrance to the room is still within their line of sight. People will generally select a seat in a public area which is closest to the entrance they used, and they will seek out a seat that is not next to an occupied one if given a choice.

- *Circulation.* Effective circulation spaces move people efficiently from place to place. The most efficient paths are arranged in a straight line, and offer an unimpeded view of the destination. If a path is too complicated, people will react to it with frustration and "instinctively" resist using it.

Personalization

Self-expression is an essential element in worker productivity and ambition. Whenever possible, there should be some allowances made for personalization of a workspace. The selection of objects or finishes in a person's area imparts a feeling of mastery and comfort. Personalization also allows for the honoring of the traditions of rank and promotion, which can have a cohesive and stabilizing effect in an organization.

ERGONOMICS AND JOB TASKS

Work design is traditionally the domain of the Industrial Engineer, however, with a background in ergonomic principles, interior designers can also contribute to this area. They are often in a position to observe and gather information during the design process that identifies and lessens potential problems.

The following signal risk factors on job tasks:

- repetitive motions
- fixed or awkward postures
- forceful hand exertions
- vibration from hand tools or equipment
- manual material handling
- unassisted lifting >25 lb.
- recurrence of slips and falls

ERGONOMIC DESIGN APPLICATIONS

Programming

Effective ergonomic design focuses on anticipating and meeting the needs of the user. Before finalizing any scheme, several common sense steps can be employed by the designer to help achieve ergonomic design goals.

- *Step 1.* Define and examine the needs of the total user population; do not concentrate only on the primary resident, but look at the needs of his or her visitors or clients and the people who serve the primary client.

- *Step 2.* Question motivations and unrealistic desires to separate them from genuine needs. The desire for "more closets," for example, may indicate a need for other kinds of storage that will be more serviceable. A wish for a

windowed corner office may come less from any practical need that from a desire for heightened status – a value that may or may not deserve consideration.

- *Step 3.* Examine and define the various tasks that each of the users has to perform. Determine what these tasks imply in terms of space, privacy, environmental control, supportive furnishings, and utilities.

- *Step 4.* Explore the interactions between various users and their furnishings and equipment. Examine alternative arrangements to determine the most convenient organization of people, furnishings, and equipment.

- *Step 5.* Bring all needs and desires into some realistic relationship not only with the project's budget and priorities but also with the underlying economic forces.

- *Step 6.* Retest and rework alternatives back through the user population as many times as is practical, and adjust the scheme as necessary before finalizing it.

Also refer to the "Furniture Systems Guide" for a detailed programming checklist.

General Design Approaches

Ergonomic guidelines have been established by drawing upon information from a number of different scientific disciplines. In spite of the specialization within the individual fields, there are several common design objectives:

- *Design for flexibility.* Designing for flexibility can be the key to solving several problems with a single approach. Select furniture and systems that can be adjusted to the greatest number of individual needs, and easily reconfigured to meet the evolution of an organization's need.

- *Consider every design choice to be part of a total, interactive system.* For example, a chair must not only fit the individual, but also the requirements of the task, and it must work within the environment in which it will be used, over time, etc.

- *Provide the most "intuitive" design solution.* In other words, design objects and spaces in a way that is natural or logical to the average person's experience. Intuitive design provides smooth information transfer. Research indicates the there are sets or natural behaviors or associations that can be expected:

  – control switches are expected to move up, to the right, or clockwise to turn on
  – people assume that water and liquid valve handles that are operated with the right hand rotate clockwise to increase flow
  – people have become conditioned to certain color meanings: red for danger, fire and hot; green for OK, go and acceptable; yellow or amber for caution, yield; and blue for cold or cool

– people's attention is drawn to bright and vivid colors, bright lights, loud noises, flashing lights, repeated sounds
– people assume a relationship between objects on the basis of their proximity; they assume that things are related somehow when they are located together, and that they cannot possibly be related unless they are together
– things that are unfamiliar may appear complex and may easily confuse people. Spaces and systems should convey one, simple organizational principle, pattern or sequence

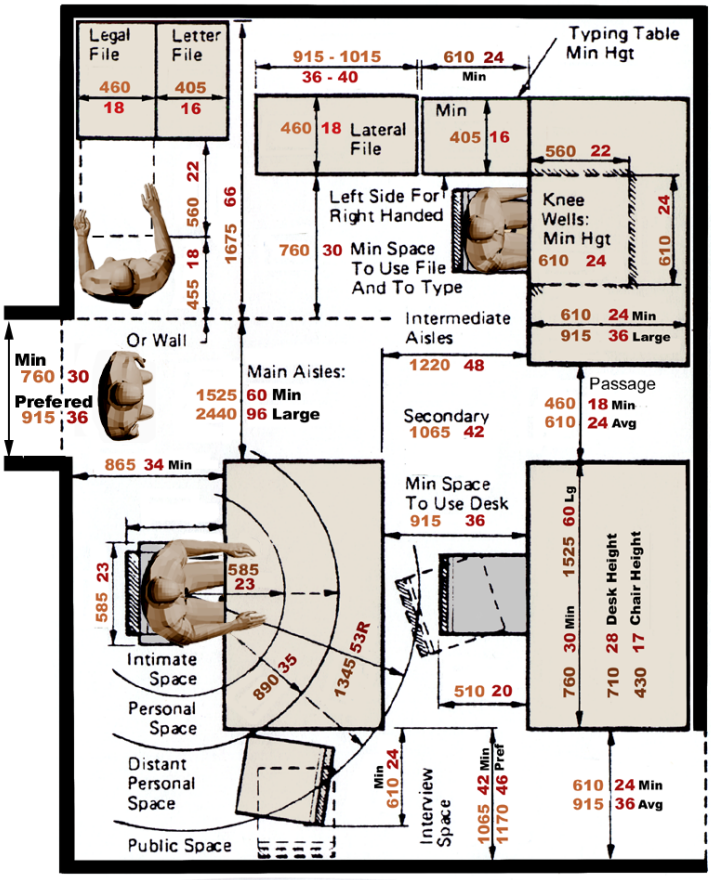
• *Make designs as safe as possible.* This is an extension of "intuitive" design, and it may prevent misuse or injury. Based upon research, designers can anticipate certain behaviors from people, and plan for them:

– people generally regard products to be safe. Thus, they proceed to touch or manipulate things without caution, and they do not check before hand.
– people don't read labels, they tend to first explore with their hands
– people take deliberate risks and shortcuts; refuse to look at and read signs or other visual warnings; this is especially strong when people become stressed or hurried
– it takes very little to distract someone
– people are generally aware of the capabilities of their bodies. For example, they assume that if an object is small enough to get a hold of, it is also light enough to pick up. They do not recognize how strains, sprains or fractures are caused, or how easily they may be thrown off balance
– people expect handrails, balconies, stages and ramps to be strong enough to support them at all times
– when about to lose their balance or fall, they instinctively reach for and grab the nearest thing

• *Design to minimize muscle fatigue.* Avoid the following:
– workspace layouts that require people to sit in a twisted position in order to watch a display or operate some control
– workspaces that require a person to reach or hold their hands above their head
– spatial or furniture layouts that require frequent lifting, stooping or squatting

Space Allocation

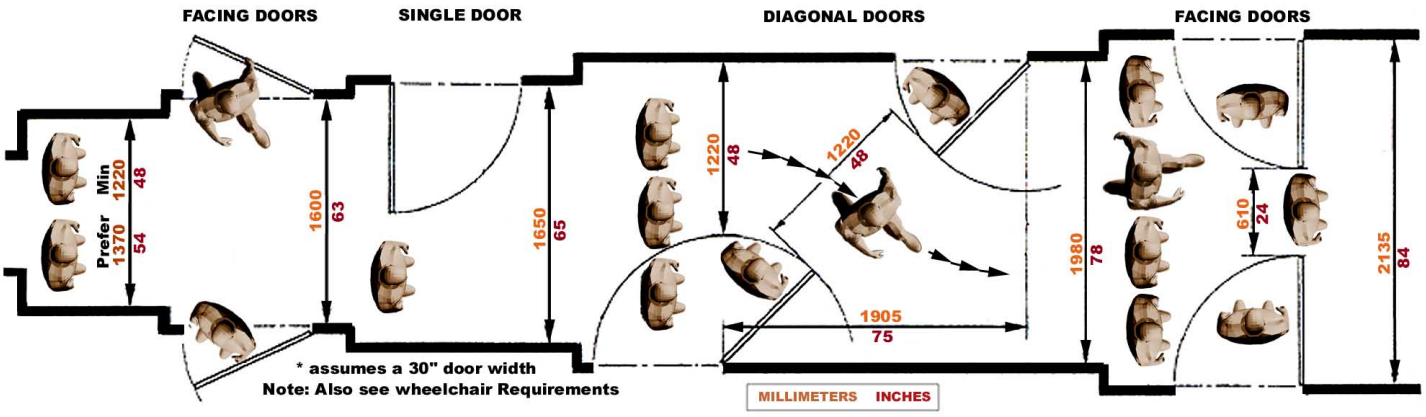
Once the designer knows the potential uses for a space, he or she can apply anthropometric data as a basis for a design scheme. Certain standard measurements can aid the designer in the allocation of space. Refer to the illustration for guidelines.



Circulation

Before laying out any circulation patterns, the designer should contact the person in charge of an area or department to learn about the general demands and workings of that work area. There is a need to discuss such issues as: which equipment is used most frequently, adjacency requirements, peak demand times, or what specialized equipment may be justified to make the job easier or safer. Once these questions have been answered, the designer can lay out optimal local traffic flow patterns within and between areas.

Anthropometric data ensure that enough space is provided for individuals to move freely and safely. Refer to the illustrations on this page for allocation guidelines.



In addition to providing enough space for individuals to move freely and safely, the design lay out should minimize the potential for them to walk unnecessarily long distances.

Storage

Storage space is a very important item in the ergonomic design of a workplace. It is important that the items used most frequently are placed closest to the worker. This optimizes time as well as reduces the number of awkward postures required performing common work tasks. In order to be effective, the storage space should be large enough to hold large batches of supplies and resources, to accommodate the busiest work periods and provide storage for supplies nearest the locations where they will be used. Again, apply the ergonomic principles of smooth information transfer, flexibility, and intuitive design when planning storage areas.

Methods of equipment storage directly effect the physical effort required to replace and remove equipment from its stored location. For example, overhead storage cabinets with doors >48" can be too heavy to maneuver. Heavy objects should not be stored close to the floor or above shoulder height. It is better to store them in the "lifting power zone" – approximately knee to chest height – to prevent fatigue and injury. Refer to the illustration, p. 12, on shelf height and depth.

General Furniture Guidelines

FURNITURE

- *What's ergonomic and what's not.* Ergonomics is a hot topic. Manufacturers are eager to label furniture and accessories "ergonomically correct" or "ergonomically designed," much like food products are liberally labeled "all natural" or "new and improved." Keep in mind that there are very few standards for ergonomic equipment and furniture, and even fewer enforceable standards. Designers should be wary of these claims, and rely on their knowledge of ergonomic principles when making selections.

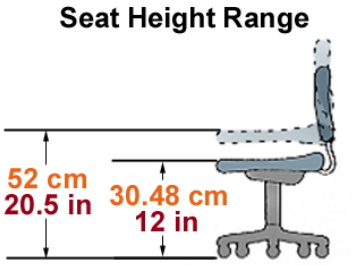
- *Flexibility and fit.* Again, the choice of furniture depends greatly upon the work that will be performed and the characteristics of the individual who will use it. The highest consideration should be for flexibility and accommodation to reduce the problems that have already been discussed. The idea that "one size fits all" is incorrect. Consider the dimensions and anatomical characteristics of the user to make sure that the furniture fits them, supports them properly, and adjusts to their activities.

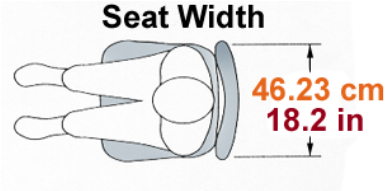
- *Safety*. Avoid sharp contact points. Base selection on the durability, balance and stability of the item's structure. Consider flammability, fire ratings, and toxic emission when specifying fabrics and upholstered seating.

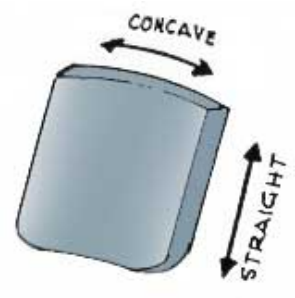
Seating

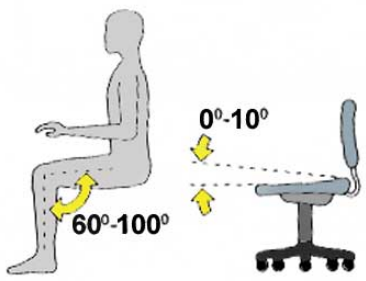
The chair is a primary interface between the body and the environment, especially in the workplace. A fully ergonomic chair can make up for many deficiencies in other equipment. Generally, it should support a wide range of postures, be easy to get in and out of, and provide proper adjustment. In the office and lodging, these features relate directly to an individual's potential for comfort and low stress posture.

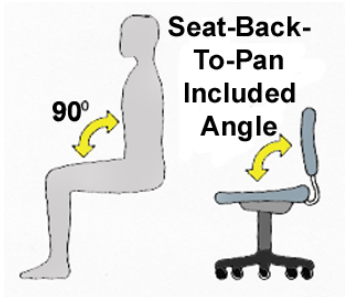
- *Office seating.* When adjusted properly, the chair should provide good lower back support, and allow the individual to rest his or her feet on the floor (or footrest). The chair should place the person within a comfortable reach the task, and position elbows at surface height. Research and debate continue on the issue of armrests in the workplace. Standard, fixed chair arms can prevent the operator from being able to get his or her legs underneath a desk or table; this forces a continuous, mild trunk bending and low back pain risk. If the specific job demands are uncertain, chairs without arms or, more preferably, with low or height-adjustable arms should be considered. Generally speaking, armrests are desirable only if they are well padded, and adjustable up and down, or they can be removed or folded away. Refer to the illustrations for the important factors in office seating.







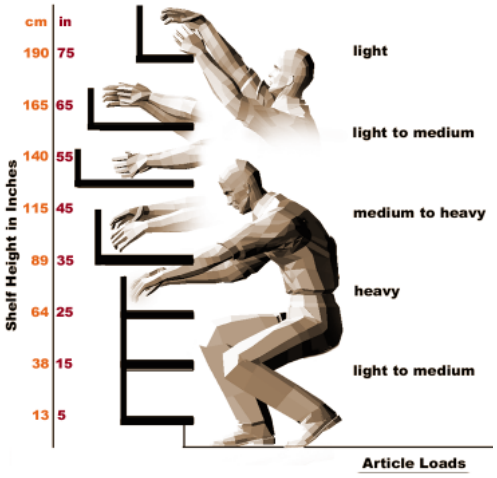




- *Sofas and upholstered chairs.* Observe the previously defined seat-length guidelines. Keep in mind that most sofa seats are too long. Select firm cushions and provide adequate kick room at the front of the seat so people can place their feet near the center of gravity when they rise.

- *Dining chairs and stools.* Select chairs and/or stools at the same time the table is chosen to get the proper seat-height to table-height relationship. Select the chair first, then select the table. The accompanying illustrations provide important guidelines for designing or selecting the proper size of table for the particular application. The guidelines shown are for adults. For children between the ages of 10-13, reduce by 15%; for younger children, reduce by about 20%.

Shelving



When selecting cabinetry or shelving-type storage units, keep in mind the nature of the potential storage items and retrieval tasks involved. This requires attention to the following:

- size and weight of the articles to be stored
- how high and how far the particular user can reach
- size, strength and mobility limitations of the user at various positions (stretching, bending, stooping, and kneeling)
- flexibility for rearrangement
- stability
- drawer control and overhead door ease of operation
- handle and latch operability
- compartment identification
- separation and control of materials inside the cabinet

Avoid the temptation to assume that shelf height is the only consideration. The sketch also illustrates the importance of shelf depth. Although it may appear wasteful not to take advantage of the total available depth of a cabinet, it is not necessarily an advantage to the user.

The need to rearrange ones immediate workspace from time to time suggests mobile cabinetry. Providing files or supplies on wheels allows the user to arrange stored materials so there is less risk from reaching or straining.

Panels

Furniture panels are available in a wide range of structures and finishes. The "Furniture Systems Guide" discusses various types of panels, their application and sound absorption properties. Ergonomic considerations for selecting panels have to do with their safety, acoustical properties, and their ability to provide adequate visual screening while allowing daylight and air circulation.

Taller panels, even when they function only as visual screens, make people feel like their space is more private. Screens between workstations should be at least 150 cm (5 ft) in height and break the line of sight in all directions by 30 cm (12 in) or more. Higher panels or demountable walls should be used around copy machines, scanners, fax machines and other noisy equipment when construction that is more durable is not feasible. Lower partitions in teamwork

areas can have an energizing effect and allow natural light and fresh air to circulate in the work area.

ACOUSTICS

Noise

Noise is defined as unwanted or excessive sound. It is a stimulant that, in the right amount, spurs productivity. However, research shows that noise contributes more to workplace distractions than poor lighting or air quality. Exposure to noise increases our mental workload, which in turn affects heart rate levels and our capacity for physical activities.

Office noisemakers like fax machines, speakerphones, and sound-emitting computers are becoming more prevalent. Since more work today is being done in teams, verbal interaction has increased. Cost-driven organizations have contributed to the rising noise level by increasing worker density. Contemporary design trends toward hard plaster walls and ceilings, wood floors, metallic finishes and expanses of glass do very little to absorb unwanted noise.

There are several solutions to reducing non-productive noise levels. Major acoustical problems may call for the services of specialized consultants, but most can be dealt with by the interior designer through planning and material selection.

Acoustical Space Planning

The most effective way to reduce the noise level in a space is by lowering occupant density. People should be located as far apart as possible, balanced against the efficient use of space. If possible, locate adjacent workers at least 8 ft. apart.

Directional characteristics of sound should be considered in layout. Since the human voice is loudest directly in front of the talker, less loud to the sides, and quietest to the rear, a designer should lay out stations so that people are oriented back to back rather than facing. Seating people side to side or in a cluster arrangement is a compromise.

Isolate noisemakers. Private offices should be located away from sounds from an elevator, conference area or bathroom. Noisy equipment like fax machines or printers should be isolated whenever possible by placing them in enclosed areas of solid or durable and insulated construction.

Finishes and Materials

Soft colors, wallcoverings and subdued lighting make any space – even an open office plan – more peaceful. In the past, acoustically rated materials represented limited choices and inattention to design characteristics. There has been significant development of these materials lately. The “Noise Reduction Coefficient” (NRC) is a standard industry rating that can aid the designer in material selection and specification. The NRC is a single number indicating the effectiveness of a material in absorbing sound. With a range of 1.00 to .00,

a NRC of .99 would indicate almost total absorption; .01 virtually none. The following chart indicates general NRC's for common materials:

- bare concrete floor = .05
- tile or linoleum on concrete = .05
- carpet (1/8" pile) = .15
- carpet (1/4" pile) = .25
- carpet (7/16" pile) = .40
- carpet over padding = up to .65
- plaster ceiling = .45
- metal pan acoustic ceiling = .60
- acoustical ceiling systems = up to .90

Since lighting fixtures cover a large amount of a ceiling's surface area, ceiling-mounted luminaires with flat lenses wider than 12 inches should be avoided. A compensating design strategy is to eliminate ceiling-mounted fixtures, use 6" wide units or select units with parabolic louvers. Ceilings should have a NRC of at least 0.75. The sound transmission classification of common partitioning materials cam be found in the "Furniture Systems Guide."

Since floors cover a large amount of surface area, they are also good targets for noise control. Carpeting floors will reduce the noise of heel clicks, chair scraping, and other annoying noises that originate from the floor. As the above chart indicates, the padding and length of pile that a designer chooses can make a substantial difference in absorbing noise.

The American Society of Interior Designers recommends that systems furniture panels have a Noise Reduction Coefficient (NRC) of at least .75. Gasketing panels prevent noise from migrating through cracks. Stagger the openings on panels on either side of a circulation path so that the line of sight and noise transfer is broken.

Noise Mitigation Systems

Another acoustical solution is to add noise mitigation, that is, to install a sound masking system. Sound masking is a sort of glorified stereo that generates broadband, low-level white noise at a constant volume. The system produces a steady whooshing noise that sounds like a well designed ventilating system.

Architectural

Every effort should be made to "plug" sound leaks around doors and through ducts and chases. Double or triple glazing windows and gasketed doors can also help. Corridors and closets can act as a sound buffer between spaces.

ERGONOMICS IN THE COMPUTER ENVIRONMENT

Over the last few years, the use of computers has risen dramatically, and will continue to do so. A person who sits at a computer more than two hours during an eight hour day, or who works more than 60 minutes at a computer without a break is considered to be a substantial user, and therefore at some risk for stress and injury.

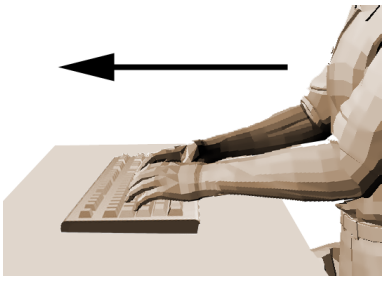
Set Up

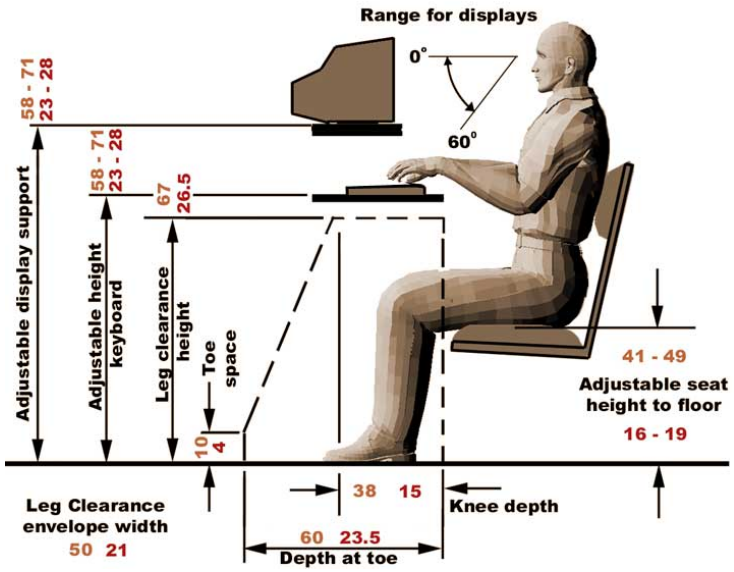
The setup of a computer workstation should allow the user to adopt optimal working postures while allowing some freedom of movement. The computer workstation should provide the necessary resources to perform other job tasks between periods of lengthy computer use. This will reduce the repetitive motion stress to the worker while providing a mental stimulus to prevent boredom.

Computer Input Devices

- *Keyboards.* There is serious research and competition among manufacturers to come up with the optimum keyboard design. Although a variety of choices exists, there are some common ergonomic design goals that should be considered.

  Most ergonomic research reinforces the desire for an ideal keying posture, that is, one in which muscle loads are minimized and the wrist is "naturally" held. Typing at a keyboard on a desk is a common condition for many computer users. In this position, it is difficult to maintain a neutral posture because the forearms sag as they tire; this puts the wrists into greater extension and restricts blood flow to the hand. It also increases the muscle load in the upper arms, shoulders and neck. Working in this posture for more than 3-4 hours invariably leads to muscle fatigue. It is more desirable to have a separate work surface such as a split-level work station or extension for the keyboard which falls at or slightly below elbow height.





There is also considerable debate about the proper slope of the keyboard. Keyboards slopes should not cause the user's wrists to flex too far back nor extend too far forward for extended periods of time.

Keyboards should not rock or slip, be easily repositioned on the work surface and detachable if available.

- *Mouse.* A recent RSI is a condition called "mouse shoulder," caused by frequently reaching for and moving a mouse. The key is to keep the mouse close to minimize reaching movements, and to keep the forearm supported. The mouse should also be placed at approximately the same height as the home-row of the keyboard for easy transfer.

- *Trackball.* This is essentially a mouse on its back. Its best virtue is the elimination of most of the arm movements that cause mouse shoulder, however, there is an increased amount of thumb and finger movement.

- *Scanners.* These devices can aid in data input by reducing the amount of direct keyboard entry and its resultant wear and tear on the hand and wrist.

Monitors or Video Display Terminals (VDTs)

There are three ergonomic concerns about monitors: eye strain, neck strain and electromagnetic emissions.

Several cost-free options are available to reduce eye strain. Most importantly, avoid natural or artificial light striking the display. Place the monitor 45 to 60 cm (1.5 to 2 ft) away from the user, and allow for personal adjustment. Preferences for viewing depth vary widely, but research indicates that a preferred viewing distance ranges between 60 and 90 cm (24 and 36 in). Lower the contrast between a bright screen and a dark background. If glare is unavoidable, consider placing an anti-glare screen over the monitor, but ensure that the image is not so degraded that it causes additional eye strain to see it clearly.

Neck strain is simple to alleviate by adjusting the height and slope of the monitor to the individual's needs. Consider a personís eye level, height, the nature of the task they are to perform and the duration of time required. Monitor height can be adjusted by placing the monitor on books or blocks of wood. As a design guideline, most workers prefer a centerline height for the screen at or slightly below eye level.

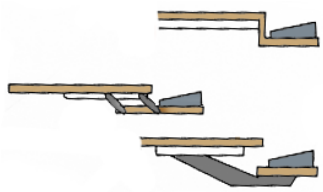
The health and safety implication of Video Display Terminals (VDTs) is a subject of serious debate and research, but no clear conclusions have resulted.

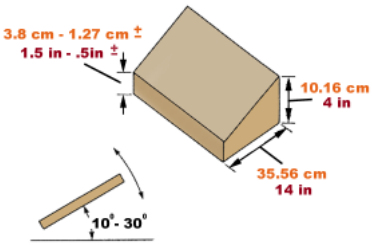
Computer Accessories

Many accessories can improve the ergonomics of the computer workstation. Some of the more popular items are listed below along with some considerations for their use:

- if the operator frequently types from hard copy or draws using computer-aided-design (CAD) while looking at drawings, or maps, provide a *flexible copy holder* directly next to the screen, and ensure that it rests at the proper distance, tilt, and eye level to reduce eye strain

- *wrist rests* may be used to improve the posture of the wrist while typing, but it is imperative that the operator places the device under the base of the palms and not under his or her wrists. Wrist rests should be should be made of soft material and allow for easy flow of motion from keyboard to mouse.





- *CPU stands* are useful when there is limited desk space, but they may restrict the leg position if they are placed in the knee well. They should be placed to the side of the desk. They should not be used if very frequent access to the CPU is required (for example, to regularly change-out discs or CDs) since this often requires risky bending, reaching or twisting motions.

- *keyboard trays* can be useful for extending the "reach" of the keyboard, or as a retrofit for a workstation that was not originally designed for keyboard use. As with wrist rests, the front edge of the tray should fit comfortably under the base of the palm, and be made of soft material. They should be sturdy and have no lip or sharp edges to pressure the wrists.

- *monitor risers* and *monitor arms* can also be a used to position the monitor at the proper eye level and tilt. This is particularly helpful to the taller user.

- *lumbar supports* for chairs typically do not improve the sitting comfort significantly enough to encourage their use; new chairs with appropriate lumbar support in the backrest are recommended instead.

- *task lighting lamps* are a good solution when operators need to look frequently or closely at small items, such as assembly, maintenance or typing from hard copy. It is also helpful to the older worker who needs higher illumination levels.

- *footrests* are very good for shorter operators whose workstations do not adjust to their height. Many now come with a tilt option so that you can easily flex or extend the ankles.

Other considerations for the design of the computer workstation can be found by following the ergonomic checklist in Attachment C of this guide.

INDOOR AIR QUALITY (IAQ)

The quality of indoor air influences the health, comfort and productivity of occupants and visitors. The Environmental Protection Agency ranks indoor air pollution among the top five environmental risks to public health. The phenomenon termed "sick building syndrome" made headlines for a time, and research began in the late '80s to identify and eliminate the contributors to the stew of emissions that can collect and circulate in a building.

Many materials in common use, as well as certain practices, can have an unfavorable impact on air quality within a building. Asbestos, long a favorite insulation material and an ingredient in various building products, is now well known as a carcinogen. The re-circulation of air in air-conditioned interiors may favor both the short-term danger of infection and the long-term risks related to exposure to low levels of air pollutants.

Traditional methods to ensure good indoor air quality relied almost exclusively on ventilation strategies – fresh air was introduced into the space to dilute contaminants that build up over time. Other more proactive and more cost-effective strategies now exist.

"Source control" strategies eliminate possible sources of contamination before they are introduced into the building. Examples include designating a building as a non-smoking building, and specifying bacteria/moisture/mildew inhibitors in paint and other materials. Limiting materials with a great deal of accessible surface area ("fleecy" materials such as carpet, upholstery and ceiling tiles) will also control the release of chemicals into the environment.

"Source isolation controls" attempt to contain sources of contamination that cannot be eliminated. For instance, buildings may contain copy machines, housekeeping chemical storage, food preparation areas, loading docks and toilet rooms. These areas can pose significant risk to the air supply in case of an accidental spill or release. All of these areas should be separately ventilated to the outside so that return air is not recirculated into the building. Building pressurization and careful location of building openings are also used to reinforce source isolation.

Installation procedures also have an effect on exposure to harmful or irritating substances. A great many user complaints come from carpet change-out. Tests indicate that carpet emissions are released upon installation, but with proper ventilation they will dissipate within 48 to 72 hours. There are some common sense guidelines for installation or remodeling:

- plan for sensitive occupants to leave the building during removal of old carpet and/or the installation of new carpet
- vacuum old carpet thoroughly before removal to minimize airborne dust particles
- provide adequate ventilation during installation and the following 72 hours
- increase fresh air ventilation to flush out remaining contaminants
- specify low emitting adhesives and carpet cushions

SAFETY AND SECURITY

General Safety

The threat of accidents is generally associated with means of travel and public streets, but indoor accidents are actually a major cause of injury and death. The National Safety Council reports that each year there are over 3 million disabling indoor fall accidents, including over 4000 deaths.

Stairways and steps pose real dangers. Rest rooms, with their slippery surfaces, hard projections, mirrors, glass, and hot water, are notorious accident locations. Kitchens – both residential and commercial – with open flames, gas or electric elements, boiling water, heated fats or other hot liquids, and sharp objects present other risks. Glass always poses a danger, particularly in the form of large windows and doors that can sometimes be virtually invisible under certain

lighting conditions. High locations such as balconies, windows and platform edges need the best possible guardrails or bars, marking, and lighting. Polished floor surfaces are a hazard especially outdoors or near entrances where water, snow, or ice can add to the risk. Small rugs and mats and the edges of larger rugs can cause falls. Projecting furniture legs and edges, or furniture that overturns easily are also involved in a surprising number of accidents. As a guide for designers, they should:

- avoid the use of rugs or chair mats that can skid or cause a trip hazard.
- specify non-slip floor surfaces wherever practical, especially if there is a possibility that they will become wet. Ensure they do not become slippery when wet.
- provide nonskid treads on stairs and clearly mark the beginning of stairway.
- avoid level changes and single steps if possible. If not, mark level change clearly through contrasting colors, material or design. Provide rails and/or safety lights.
- ensure that steps and stairs are free of obstructions.
- eliminate sharp edges, corners on cabinetry and furniture.
- ensure adequate clearances for circulation, especially around machinery or moving objects.
- ensure that no cords need to be stretched across the workstation resulting in a trip or fire hazard. Wherever practical, provide several power outlets throughout the workstation, consider ceiling supply or access flooring to minimize cable hazards.
- select and place light fixtures carefully to ensure adequate lighting in storage closets and hallways.
- provide emergency lights at key locations.
- observe glass doors and large windows under as many lighting conditions as possible to anticipate any potential hazard they present, and offer correction.
- do not use large ceiling-to-floor glass windows or doors without appropriate barriers.
- control access to pools and other hazards in lodging.
- provide thermostatically controlled mixing faucets for tubs and showers.

Fire Safety

Code compliance is not, in itself, assurance that all fire safety issues have been fully addressed by the designer. The dangers are multiplied by modern closed spaces with artificial ventilation, often on high floors where rescue access is difficult.

In addition to the adequate number, size and marking of exit routes, there is the specialized equipment such as smoke detectors, fire alarms, extinguishers, sprinkler systems, and hose connections that need to be integrated into the project design. The interior designer can also make it a point to avoid choosing synthetic materials that give off toxic fumes when burning.

Security

This is an issue closely related to safety and, unfortunately, an increasingly important consideration particularly in areas where social conditions have brought about an increase in robbery, vandalism and even terrorism. Design

cannot control every aspect of such problems, but both basic planning and suitable details and equipment can help to minimize risks. Dark halls, and hidden areaways invite trouble, while open and visible access points are somewhat self-protecting. Ensure adequate lighting fixtures, especially in and around parking areas and at entry doorways.

HEALTH HAZARDS

In addition to safety hazards that create the possibility of injury, building interiors can create other problems that may impinge on occupants' health. Concern has recently developed for hazards that may be associated with exposure to electromagnetic fields (EMF). Such magnetic fields are created wherever electrical devices are in use. Where small currents are involved, the strengths of the fields are not great and their levels fall off short distances from the sources. There is strong disagreement among researchers about the levels of risk involved EMF exposure.

Other health hazards have been traced to the presence of lead in paints and water that comes from pipes or plumbing devices such as faucets. The danger is of special concern in projects where children will be the user/occupants. Radon gas in interiors and even very small amounts of mercury that might come from fluorescent lighting tubes or from discarded batteries is an additional source of health problems.

Health hazards related to the deprivation of full-spectrum lighting are discussed in the "Light and Lighting" guide.

TEMPERATURE CONTROL

The temperature of our environment can have a significant effect on our physical capacity. As we all know, when it is excessively hot or humid we tend to move slower and become tired faster, because these conditions require more energy. Similarly, cold environments can cause a tightening of the muscles which also limits our ability to perform some tasks. Climate control is particularly important for minimizing effort and for the reduction of muscle injury.

It is often assumed that blanket conditioning of all spaces will effectively accommodate all types of organizational needs. This is not the case. Consequently, when a new design concept is introduced into a building, modification of the building's base systems (like cooling, ventilation, ceilings or acoustics) also needs to be considered in the design.

Temperature control is one area where it may be necessary and more economical to consult an expert before a new scheme is implemented.

Wherever possible, variations in environmental conditions should be controllable within a facility. Special consideration should be given to weather patterns for unprotected or frequently exposed areas such as loading docks, outdoor passages, and unconditioned storage spaces.

ENVIRONMENTAL CONSIDERATIONS

The interior designer can participate in a number of activities aimed at the recovery and preservation of our environment through waste reduction, reclamation and recycling.

Many manufacturers have initiated programs aimed at environmentally sound ways of handling waste. First, the goal is to reduce the amount of waste generated in the manufacturing process – often referred to as "pre-cycling." Second, they have found ways to re-claim used materials from the job site, recondition those materials, and return them at a substantial savings over new products. Finally, manufacturers are finding many ways to recycle previously wasted materials into economically feasible uses, and make these products available to the consumer.

Interior designers can make a significant contribution to these efforts by working with environmentally responsible manufacturers, especially in the area of carpet purchase. About six billion pounds of carpet is replaced in the United States each year. Federal agencies are directed by Executive Order to enhance the purchase of products, including carpet, which contain recycled materials or that are otherwise environmentally preferable. At the present time, carpet fibers made from post-consumer recovered material commonly include polyester and nylon, among others.

As this technology progresses, more and more construction materials can also be re-cycled. Some manufacturers of acoustical ceiling tiles will take back products, rejuvenate or recycle them, and provide them for resale. This saves money and is an environmentally sound alternative that should be pursued.

FUTURE TRENDS

Designing for the comfort and safety of users is has always been a basic challenge. In addition, work populations are increasingly diverse and organizations are evolving at increasing speed. Several trends in technology and workstyle are emerging:

- mobile workstations, portable offices and just-in-time workspaces are in greater demand. More desks, filing cabinets and office equipment will need to be on wheels.
- there is a trend toward different work plane heights. Combination sit/stand workstations are on the increase.
- communication, computer and electrical hook-up cabling must be flexible for maximum reconfiguration. Consider cables that descend from overhead tracks; they're ADA compliant as a bonus. Fiber optic cabling will be increasingly used.
- there will be increased biofeedback from office equipment
- computer size and shape is shrinking; laptops offer great flexibility, and second and third monitors will be common

5

CONCLUSION

This guide is intended to increase the understanding of all readers in the fundamentals of ergonomics in the work environment. Informed readers become informed users.

Finally, it is probably safe to say that ergonomic problems are now, or soon will be, everyone's problems. Rather than relying on researchers and manufacturers, many of the best and most creative solutions can come from informed designers who work with opinions from their users and apply the basics of ergonomics.

ATTACHMENT A: GLOSSARY OF TERMS

adaptation	Adjustment to conditions in the environment. Adaptation to temperature changes is referred to as *acclimatization.*
anthropometry	The study of the physical dimensions of people, including size, breadth, girth, distance between anatomical joints, and joint range of motion.
awkward posture	A deviation from the neutral position of any particular joint. Examples include extreme flexing, extending, bending or rotating parts of the body, reaching behind the trunk, holding arms above the shoulders, etc.
biomechanics	The application of mechanical principles, such as levers and forces, to the analysis of body-part structure and movement.
bursitis	Inflammation of a sac found near a joint such as the shoulder or knee. The inflammation is attributed in some cases to excessive use of the joint.
capacity	The maximum ability of a person to perform in a given set of conditions.
Carpal Tunnel Syndrome	Entrapment of the median nerve of the hand and wrist in the passageway (tunnel) through the carpal bones of the wrist; usually results in numbness in the fingers and pain on gripping.
Cathode-ray Tube (CRT)	Element providing the screen for television or computer monitor.
contact stress	A type of trauma inflicted by direct contact of various body parts with work surfaces or tools.
Cumulative Trauma Disorder (CTD)	[See Work-related Musculoskeletal Disorder.]
displacement	The difference between the initial position of an object and its position later. In Biomechanics, the object may be the body or a particular body segment.
dynamics	The biomechanical aspects of the human body in motion.
efficiency	The effectiveness with which a task or operation is done, usually measured in energy spent, cost or time required.
endurance	The ability to sustain an activity over time.
engineering controls	Physical changes to work stations, equipment, materials, facilities, or any other relevant aspect of the work environment that reduce or prevent exposure to ergonomic risk factors.
environment	The circumstances, conditions, and influences that affect the behavior and performance of people in the workplace; physical factors such as noise, vibration, lighting, temperature humidity and air flow as they factor in job design.

Ergonomics	The field of study that seeks to fit the job to the person. This is achieved by the evaluation and design of workplaces, environments, jobs, tasks, equipment, and processes in relationship to human capabilities and interactions in the workplace.
fixed posture	Prolonged muscle contraction without movement. Examples include stringing cable overhead or prolonged gripping of a hand tool.
heavy effort	Physical work that can be sustained for only one hour or less; also the handling of objects weighing more that 18kg (40 lb.).
job design	The arrangement of tasks over a work shift.
kinetics	In Biomechanics, the study of the forces that influence movement of the human body.
lateral	Toward the side of the body away from the midline.
light assembly tasks	Work with low energy expenditure demands that are often performed in a seated position.
light effort	Physical work that may be sustained for at least eight hours a day.
moderate effort	Physical work that can be sustained for about two hours without a major work break; also the handling of objects weighing up to 18 kg (40 lb.).
musculoskeletal	Pertaining to the muscles, bones, and joints.
Noise Reduction Coefficient (NRC)	A standard industry rating indicating the effectiveness of a material in absorbing sound.
overuse syndrome	[See Work-related Musculoskeletal Disorder.]
posture	The relative arrangement of body parts, specifically the orientation of the limbs, trunk, and head during a work task.
productivity	The amount of good product completed during a shift in relation to the amount of input needed to produce it.
psychosocial	Factors that produce both psychological and social effects.
recovery time	Work periods when a task demands are light or when rest breaks are scheduled to permit a person to recover from heavy effort work or exposure to an environmental extreme.
risk factors	Attributes, experiences, and exposures that increase the probability of occurrence of WRMD.

routine exposure	Approximately daily; three or more times per week.
Sound-Transmission Class (STC)	A number that represents the ability of a barrier or an assembly to reduce the intensity of sound as it passes through it.
stress	Physiological, psychological, or mental effects that may produce fatigue or degrade a personís performance.
task	The smallest unit of work that will be used for assessing worker exposure; a distinct activity.
task analysis	An analytical process that measures behavior on a job against time to determine the demands of the job.
tendonitis	Inflammation of a tendon usually associated with repetitive, forceful exertions, often involving rotation around a joint.
Video Display Terminal (VDT)	The screen unit used to display computerized information.
work analysis	The systematic investigation of work activities to identify risk factors, evaluate their probable causes, and develop controls to minimize or eliminate the identified risk factors.
Work-Related Musculoskeletal Disorder (WRMD or WMD)	Illness or injury of the muscles, tendons, ligaments, peripheral nerves, joints, bones, and or supporting blood vessels in the body that are associated with routine exposure to ergonomic risk factors such as repetitive tasks or forceful exertion. Commonly used terms, such as *"Cumulative Trauma Disorder (CTD)," "Repetitive Strain Injury or Illness," "Repetitive Motion Disorder, Injuries or Illness,"* and *"Repetitive Stress Injury or Illness"* are included in this definition.
workstation	An individual's work area, such as a desk, cubical, or a maintenance or inspection station

ATTACHMENT B: REFERENCES

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Internet Sites and Other Links

Cornell University's ergonomics web

Ergobilt web

ErgoWeb

RSI Network

Scott Wright's *Ergonomic Resources* home page

U.S. Occupational Safety and Health Administration, and the *U.S. National Institute for Occupational Health and Safety's* ergonomics pages

http://www.engi.umich.edu/dept/ioe/c4E/projects/index.html

http://www.acq.osd.mil

Computer Electronic Accommodation Program
Defense Medical Information Management
Office of the Assistant Sec. of Defense (Health Affairs)
(703) 681-8811/DSN: 761-8811/fax: 703 6819075
cap@ga.osd.mil
http://www.ha.osd.mil/hpcap2.html

For information on making reasonable accommodation, assistance in construction and renovation specs, and or referral to other ADA information agencies:
ADA InfoCalling Line
1-800-ADA-WORK

ATTACHMENT C: CHECKLIST FOR COMPUTER WORKSTATIONS

This checklist can be used to evaluate present or proposed workstation needs. It is not meant to be an exhaustive list, and the appropriate rating will depend upon the specific population of users, the nature of the task, and the work environment. Ratings range: S=Satisfactory; C=Compromise, but acceptable; U= unacceptable.

	Satisfactory	Compromise	Unacceptable
Chairs			
Is the range of height adjustment adequate?	( )	( )	( )
Can the chair height be adjusted easily?	( )	( )	( )
Can the chair height be adjusted from a seated position?	( )	( )	( )
Are footrests available?	( )	( )	( )
Does the chair have a high backrest?	( )	( )	( )
Does the backrest tilt back?	( )	( )	( )
Is the tension of the backrest adjustable?	( )	( )	( )
Does the backrest lock in position?	( )	( )	( )
Is the lumbar support sufficient?	( )	( )	( )
Does the lumbar support adjust up and down?	( )	( )	( )
Does the chair have armrests?	( )	( )	( )
Are armrests appropriate for the job?	( )	( )	( )
Do armrests interfere with movement or reach?	( )	( )	( )
Are armrests sufficiently padded?	( )	( )	( )
Are armrests adjustable up and down?	( )	( )	( )
Are armrests adjustable side to side?	( )	( )	( )
Do armrests prevent the user from pulling up close to the task?	( )	( )	( )
Does the seatpan have a rounded front edge?	( )	( )	( )
Does the seatpan tilt?	( )	( )	( )
Is the seatpan tension adjustable?	( )	( )	( )
Does the seatpan position lock?	( )	( )	( )
Does the chair have a 5-leg base?	( )	( )	( )
Is the chair free from pinch points or rough surfaces?	( )	( )	( )
Are casters matched to the type of floor surface?	( )	( )	( )
Are all adjustments safe against unintentional release?	( )	( )	( )
Does the chair material and fabric meet applicable fire codes?	( )	( )	( )

	Satisfactory	Compromise	Unacceptable
Work Surfaces			
Are surface heights easily adjustable to the user or the task?	( )	( )	( )
Are corners and edges rounded and smooth?	( )	( )	( )
Are working surfaces stable when loaded?	( )	( )	( )
Is the surface thin enough to provide adequate leg space?	( )	( )	( )
Is the range of height adjustability acceptable?	( )	( )	( )
Are surfaces non-reflective?	( )	( )	( )
Work Space			
Is there adequate space to perform all tasks?	( )	( )	( )
Is there adequate space for all equipment?	( )	( )	( )
Can the workspace be adapted for right or left-hand use?	( )	( )	( )
Are all items of equipment and information that are frequently used within normal reach of the user?	( )	( )	( )
Does the arrangement of the work area allow access to all job aids without excessive bending or reaching?	( )	( )	( )
Is the work area free of pinchpoints and protrusions?	( )	( )	( )
Is there adequate legroom so the user can adopt different postures?	( )	( )	( )
Is the area under the work surface free from obstructions that might interfere with movements between different tasks?	( )	( )	( )
Is hardware recessed or flush-mounted to prevent hazards?	( )	( )	( )
Is the location, size of equipment such that it can be easily operated and maintained by at least the 5th percentile (female) to 95th percentile (male) of the population who will use it?	( )	( )	( )
Are workstations positioned to avoid glare and reflection?	( )	( )	( )
Panels			
Do panels provide sufficient privacy?	( )	( )	( )
Do panels hold noise to an acceptable level?	( )	( )	( )
Does panel height allow for adequate natural light and air circulation?	( )	( )	( )

	Satisfactory	Compromise	Unacceptable
Keyboards			
Is the height of the keyboard at the "home row" adjustable?	( )	( )	( )
Can the keyboard be easily repositioned on the work surface?	( )	( )	( )
Does the keyboard rock or slip in use?	( )	( )	( )
Does the operator's wrists rest in a neutral position when keying?	( )	( )	( )
Is the wrist rest soft yet offer adequate support?	( )	( )	( )
Is the keyboard reach sufficient?	( )	( )	( )
Can the keyboard surface be tilted?	( )	( )	( )
Is the mouse at the same height as the keyboard?	( )	( )	( )
Does the area directly in front of the keyboard keep the forearm supported?	( )	( )	( )
Monitors			
Is the monitor size sufficient for the task?	( )	( )	( )
Can the monitor be placed at the proper eye level?	( )	( )	( )
Is the contrast and brightness easily adjustable?	( )	( )	( )
Can monitor be placed at user-preferred distance?	( )	( )	( )
Can display be tilted up and down?	( )	( )	( )
Can display be rotated side to side?	( )	( )	( )
Miscellaneous/Accessories			
Is there a copy holder for operators who frequently work from hard copy or drawings?	( )	( )	( )
Can cables be routed out of the way to avoid tripping?	( )	( )	( )
Are task lights provided as necessary?	( )	( )	( )
Is the user's view free from glare?	( )	( )	( )
Is the ambient lighting in the area of the VDT minimized?	( )	( )	( )
Is adequate space provided for storage of copies, handbooks, documents, reference materials and personal belongings?	( )	( )	( )